Advisory Circular

Subject: AIRWORTHINESS APPROVAL OF REQUIRED NAVIGATION PERFORMANCE (RNP)

Date: DRAFT 8
Initiated By: AIR-130

AC No: 20-RNP
Change:

1. PURPOSE. This advisory circular (AC) establishes an acceptable means, but not the only means, of obtaining airworthiness approval for Required Navigation Performance (RNP RNAV) as defined within the AC. Like all Federal Aviation Administration (FAA) AC's, compliance with this AC is not mandatory, and the AC does not constitute a regulation. This AC provides applicants guidance for one method to ensure airworthiness certification for RNP RNAV operations. In lieu of following this AC without deviation, an applicant may elect to follow an alternative method. However, the FAA must still verify this alternative method as an acceptable means of complying with Title 14 of the Code of Federal Regulations (14 CFR). Since explicit compliance with this AC is not mandatory, the terms "shall" and "must" apply only to applicants seeking to follow this AC as a means to achieve airworthiness approval.

2. CANCELLATION.

3. RELATED FEDERAL AVIATION REGULATIONS**.** 14 CFR parts 21, 23, 25, 27, 29, 43, 91, 121, and 13.

4. RELATED READING MATERIALS**.**

a. Federal Aviation Administration (FAA) Orders and Technical Standard Orders (TSO). You may obtain copies of these documents from the Department of Transportation, FAA, Aircraft Certification Service, Aircraft Engineering Division, AIR-130, 800 Independence Avenue, SW., Washington, D.C. 20591, or on the FAA's Aircraft Certification web site at http://www.faa.gov/avr/air/airhome.htm.

(1) TSO-C60b, Airborne Area Navigation Equipment Using Loran-C Inputs;

(2) TSO-C115b, Airborne Area Navigation Equipment Using Multi-Sensor Inputs;

(3) TSO-C129a, Airborne Supplemental Navigation Equipment Using the Global Positioning System (GPS);

(4) TSO-C144, Airborne Global Positioning System Antenna;

(5) TSO-C145, Airborne Navigation Sensors Using the Global Positioning System (GPS) Augmented by the Wide Area Augmentation System (WAAS);

(6) TSO-C146, Stand-Alone Airborne Navigation Equipment Using the Global Positioning System (GPS) Augmented by the Wide Area Augmentation System (WAAS);

(7) Order 8400.11, IFR Approval of Differential GPS Special Category I Instrument Approaches Using Private Ground Facilities; and

(8) Order 8400.12A, Required Navigation Performance 10 (RNP-10) Operational Approval.

b. FAA Advisory Circulars. You may obtain copies of these documents from the Department of Transportation, Subsequent Distribution Office, SVC-121.23, Ardmore East Business Center, 3341 Q 75th Ave, Landover, MD 20785. The Advisory Circular Checklist (AC 00-2) is available at http://www.faa.gov/abc/ac-chklst/actoc.htm. The advisory circular checklist contains status and order information for the FAA advisory circulars.

(1) AC 20-115B, Radio Technical Commission for Aeronautics, Inc. Document RTCA/DO-178B;

(2) AC 20-129, Airworthiness Approval of Vertical Navigation (VNAV) Systems for Use in the U.S. National Airspace System (NAS) and Alaska;

(3) AC 20-138A, Airworthiness Approval of Global Navigation Satellite Systems (GNSS) Equipment;

(4) AC 21-40, Application Guide for Obtaining a Supplemental Type Certificate;

(5) AC 23-8A, Flight Test Guide for Certification of Part 23 Airplanes;

(6) AC 23.1309-1C, Equipment, Systems, and Installations in Part 23 Airplanes;

(7) AC 25-4, Inertial Navigation Systems;

(8) AC 25-7, Flight Test Guide for Certification of Transport Category Airplanes;

(9) AC 25-11, Transport Category Airplane Electronic Display Systems;

(10) AC 25-15, Approval of Flight Management Systems in Transport Category Airplanes;

(11) AC 25.1309-1A, System Design and Analysis;

(12) AC 27-1B. Certification of Normal Category Rotorcraft;

(13) AC 29-2C, Certification of Transport Category Rotorcraft;

(14) AC 90-79, Recommended Practices and Procedures for the Use of Electronic Long-Range Navigation Equipment;

(15) AC 90-82B, Direct Routes in the Conterminous United States;

(16) AC 90-94, Guidelines for Using GPS Equipment for IFR En Route and Terminal Operations & for Nonprecision Instrument Approaches;

(17) AC 90-96, Approval of U.S. Operators and Aircraft to Operate under Instrument Flight Rules (IFR) in European Airspace Designated for Basic Area Navigation (BRNAV/RNP-5);

(18) AC 90-RNP, Required Navigation Performance (RNP) Implementation in the United States National Airspace System.(NAS)

(19) AC 91-49, General Aviation Procedures for Flight in North Atlantic Minimum Navigation Performance Specification Airspace;

(20) AC 120-29, Criteria for Approving Category I and Category II Landing Minima for FAR 121 Operators; and

(21) AC 120-33, Operational Approval of Airborne Long-Range Navigation Systems for Flight within the North Atlantic Minimum Navigation Performance Specification Airspace.

c. RTCA, Inc. Documents. You may purchase copies of these documents from RTCA, Inc., 1140 Connecticut Avenue, NW. Suite 1020, Washington, DC 20036; or purchase them on-line at http://www.rtca.org/.

(1) RTCA/DO-160D, Environmental Conditions and Test Procedures for Airborne Equipment;

(2) RTCA/DO-178B, Software Considerations in Airborne Systems and Equipment Certification;

(3) RTCA/DO-180A, Minimum Operational Performance Standards for Airborne Area Navigation Equipment Using a Single Collocated VOR/DME Sensor Input;

(4) RTCA/DO-187, Minimum Operational Performance Standards for Airborne Area Navigation Equipment Using Multi-Sensor Inputs;

(5) RTCA/DO-194, Minimum Operational Performance Standards for Airborne Area Navigation Equipment Using Loran-C Inputs;

(6) RTCA/DO-200A, Standards for Processing Aeronautical Data;

(7) RTCA/DO-201A, Standards for Aeronautical Information;

(8) RTCA/DO-208, Minimum Operational Performance Standards for Airborne Supplemental Navigation Equipment Using Global Positioning System (GPS);

(9) RTCA/DO-229B, Minimum Operational Performance Standards for Airborne GPS/WAAS Equipment;

(10) RTCA/DO-236A, Minimum Aviation System Performance Standards: Required Navigation Performance for Area Navigation; and

(11) RTCA/DO-254, Design Assurance Guidance for Airborne Electronic Hardware.

d. GPS Standard Positioning Service Signal Specification, June 2, 1995. Copies of this document and general information related to GPS may be requested at http://www.navcen.uscg.mil/gps/geninfo/.

e. Department of Defense Interface Control Document (ICD) ICD-GPS-200C, Navstar GPS Space Segment/Navigation User Interface. You may obtain copies of the civil version of this document from the GPS Joint Program Office, SSD/CZ, Los Angeles AFB, CA 90006; or at http://www.navcen.uscg.mil/gps/geninfo/.

f. National Imagery and Mapping Agency (NIMA) Technical Report NIMA TR 8350.2, World Geodetic System 1984, Its Definition and Relationships with Local Geodetic Systems. You may obtain copies of this document at http://www.nima.mil/.

g. FAA National Airspace System Architecture Version 4.0. An electronic version of this document and architecture updates are available at http://www.faa.gov/nasarchitecture/.

h. FAA Specification Wide Area Augmentation System (WAAS), FAA-E-2892B. This document is available on-line at http://gps.faa.gov/.

i. DOD/DOT 1999 Federal Radionavigation Plan (FRP). DOT publishes the FRP biannually and you may order copies through the National Technical Information Service, Springfield, VA 22161; or at http://www.ntis.gov/.

5. BACKGROUND. The International Civil Aviation Organization (ICAO) recognized a need for dramatic improvements to the existing air navigation system. To meet this need, an ICAO Special Committee of Future Air Navigation Systems (FANS) developed a new concept expressed in terms of communication, navigation, surveillance and air traffic management, "CNS/ATM." To obtain benefits under CNS/ATM and improve operational flexibility, accurate, repeatable and predictable navigation performance, or Required Navigation Performance (RNP), must exist.

To build upon the benefits of CNS/ATM concept and RNP, geographic fixes will define the future operating environment. Ground-based navigation aids will no longer restrict development of routes and instrument procedures. While this concept, known as Area Navigation (RNAV), is not new, air traffic service providers employed RNAV operations without full confidence in navigation accuracy. However, the standards in RTCA/DO-236A integrate the concepts of RNP with RNAV providing the necessary levels of confidence for a variety of operations.

In essence, RTCA/DO-236A contains the Minimum Aviation System Performance Standards (MASPS) for RNAV systems operating in an RNP RNAV environment. These standards provide procedures designers, avionics manufacturers, avionics technicians, air traffic service providers and aircraft operators the guidance and tools to benefit from improved navigation capabilities and develop more efficient world-wide operations.

To fully realize the benefits of RNP, the standards in RTCA/DO-236A are compatible with the definitions of RNP developed by the ICAO Review of the General Concept of Separation Panel (RGCSP). However, in contrast to the RGCSP's definition of RNP, the DO-236A standards introduced unique requirements to assure navigation performance accuracy by managing and mitigating operational risk through its specifications for containment integrity, containment continuity, path definition, path steering, position estimation and area navigation functions.

To differentiate generic applications of RNP under the RGCSP's concept and the specific requirements for RNP in DO-236A and this AC, this AC adopts the term "RNP RNAV." This term merges the accuracy standards in the ICAO RNP Manual with the containment/integrity requirements in RTCA/DO-236A resulting in the RNP RNAV standards in this AC.

Specification of RNP RNAV includes performance and functional capabilities that may vary by RNP RNAV type. The performance requirements include an accuracy requirement (the RNP value) along with integrity and continuity requirements. A number, in Nautical Miles (NM), represents the RNP RNAV accuracy requirement. This number represents the 95% total system error in both along-track and cross-track dimensions. For example, "RNP 0.3" invokes a requirement to sustain navigation accuracy within 0.3 NM of your desired track 95% of the time.

The integrity requirements for RNP RNAV is specified with a fixed relationship to RNP and a maximum risk probability dimension known as a containment limit. These containment limits support application of RNP RNAV as a tool for aircraft separation and/or obstacle/terrain clearance. Air traffic service providers should also consider an obstacle rich environment, potential weather factors, high traffic density, limited communications or surveillance, and other local factors in their operational safety assessments.

This AC defines the certification basis, upon which operational approvals may be based. In contrast, AC 90-RNP describes the operational implementation of RNP RNAV in detail. RNP-based operations may include:

Operation	RNP Type	Example Application
Oceanic/Remote	RNP - 10	50NM Separation
Oceanic/Remote	RNP - 4	30/30 NM Separation
Enroute Domestic	RNP-2 RNAV	8NM Route Spacing
Terminal Area	RNP-1 RNAV	4NM Spacing
Approach	RNP-0.3 RNAV	LNAV (Non-Precision Approach, NPA)
Approach	RNP-0.3 RNAV	LNAV/VNAV (Approach Procedure with Vertical Guidance, APV)

Note 1: Sovereign states may develop related navigation operations. In some cases (e.g., Basic area navigation (BRNAV) in Europe), ATS providers may base operations solely on RNP accuracy goals. These RNP applications may mitigate the integrity and continuity risks through requirements for radar coverage and/or coverage by conventional ground-based navigation aids.

Note 2: There is no intent to limit RNP operations to solely the operations in this list. For example, an ATS provider may develop RNP-0.3 RNAV terminal area operations.

6. DEFINITIONS.

REQUIRED NAVIGATION PERFORMANCE (RNP) A statement of the *navigation performance accuracy* necessary for operation within a defined airspace. Note that there are additional requirements, beyond accuracy, applied to a particular RNP type.

RNP TYPE RNP types are established according to navigational performance accuracy in the horizontal plane, that is, lateral and longitudinal position fixing. The type is identified by an accuracy value expressed in nautical miles.

RNP-(x) RNAV A designator used to indicate the minimum navigation system requirements needed to operate in an area, on a route or on a procedure (e.g., RNP-1 RNAV, RNP-4 RNAV). The designator invokes all of the navigation system requirements specified in this document. The term RNP RNAV type is used to refer to a generic RNP(x)RNAV type.

RNP AIRSPACE Area(s), route(s), or procedure(s) where minimum navigation performance requirements have been established and aircraft must meet that performance while flying in the designated environment.

(if retained/used in the document, standardize across documents, e.g., FRP, NAS 4.0 etc.

7. AIRWORTHINESS CONSIDERATIONS.

a. Airworthiness Approval. RNP RNAV applies to the performance and capability of the aircraft system, and as such, the certification of RNP RNAV requires the applicant to obtain RNP RNAV airworthiness approval via the Type Certificate (TC) or Supplemental Type Certificate (STC) process. Applicants should also obtain AC 21-40, an Application Guide for Obtaining a Supplemental Type Certificate.

Compliance with this AC shall be documented in the Aircraft (Rotorcraft) Flight Manual (Supplement), as described in Paragraph 9.b of this AC.

b. Operational Approval. The applicant must obtain an operations approval (or letter of authorization for general aviation) before conducting RNP RNAV operations. Applicants should contact the appropriate Flight Standards District Office to gain operations approval. AC 90-RNP provides guidelines for Operational Approval of RNP RNAV.

8. REQUIRED NAVIGATION PERFORMANCE AREA NAVIGATION (RNP RNAV). Applicants seeking airworthiness approval for RNP RNAV must comply with the performance and functional requirements defined in Sections 2 and 3 of RTCA/DO-236A except as identified below. Also, the installation must satisfy the ~~appropriate~~ criteria in AC 20-130A (multi-sensor systems) or AC 20-138 (GNSS equipment) unless conflicting with this AC.

a. General exceptions (apply to all RNP RNAV types)

(1) Vertical navigation, time of arrival control: The requirements and guidance material within RTCA/DO-236A for vertical navigation and time of arrival control are not relevant to this AC and do not relate to RNP RNAV airworthiness approval.

(2) *Position Estimation Function:* The requirements of Section 3.1 of RTCA/DO-236A and the following sensor-specific requirements apply.

(i) GNSS. If the system's position estimation function uses GNSS (including GPS/RAIM, GPS/WAAS, or GPS/LAAS), the system must consider non-aircraft fault modes (e.g. satellite failure). The system must also ensure satellite failure containment integrity of 10^{-7} per hour, in lieu of 10^{-5} per hour. In other words, the hazard class for failure cases affecting only the aircraft is Major, while failure cases affecting multiple aircraft is hazardous.

- For systems using GPS/RAIM to monitor satellite failures, the missed detection probability of a satellite failure must be better than or equal to 10^{-3}.

- For systems using GPS/WAAS or GPS/LAAS, the system must use the standard protection levels for those applications (reference RTCA/DO-229C and RTCA/DO-254A).

(ii) Inertial navigation: An integrated inertial navigation system within a multi-sensor platform (such as a flight management system), or with a GPS, can provide continuous navigation during an outage of underlying navaids or when there is insufficient navigation coverage to support the desired RNP RNAV environment. If an inertial system~~'~~ is part of an RNP RNAV-compliant system, the equipment must provide real-time modeling of the inertial performance and account for the potential impact of inertial drift when coasting and demonstrating compliance with Section 2.1 and 2.2 of RTCA/DO-236A. For RNP RNAV systems designed with an integrated inertial system, the installation instructions for the equipment should stipulate requirements for the inertial system.

(3) The concept of RNP has frequently been associated with sensor-independent operations. While sensor-generic procedures are possible within the context of the flight crew procedures and interface, sensor-independent operations are not feasible. There are a number of issues that impede sensor-independent procedures, some of them including:

- Operators must equip aircraft with specific sensors and must demonstrate the performance of these sensors for RNP certification;
- sensors reliant on external signals (such as those from navigation aids) cannot function outside the coverage of the external signal;
- the air traffic service provider must ensure the signal-in-space performance of navigation aids meets the tolerances required for RNP RNAV operations (e.g., the database coordinates of ground-based navaids are critical for RNAV, but do not affect conventional ground-based operations);
- outages of ground-based navigation aids can affect the aircraft operational capability;
- aircraft navigation systems do not identify and verify the valid identification transmitted from ground-based navigation aids, and therefore do use navaids that are broadcasting test signals; and
- aircraft traffic management (ATC function) must have an ability to accurately predict the operational capability of arriving aircraft, and without having sensor specific performance and operations criteria, there is no predictive capability.

Due to these and other factors, this AC defines sensor-specific criteria to augment the requirements of DO-236A.

(i) Predictive RNP Capability. ~~This AC requires a predictive RNP capability. This capability forecasts whether or not a specific level of RNP RNAV will be available during the times and locations for desired RNP RNAV operations. The pilot must also have a means to identify the availability of facilities potentially impacting the RNP RNAV operations. This capability may be resident in the aircraft's RNP RNAV equipage, or the capability may be available through a ground operation or service.~~AC 90-RNP, Appendix 1, paragraph 4.b describes the operational requirement for the flight crew to be able to assess the expected RNP capability for a particular operation. This capability may be inherent in the operating procedures, resident in the aircraft's RNP RNAV equipage, or accessible through a ground-based operation or service via voice or datalink communications.

(A) Operating procedures may only be suitable if the RNP compliance is based on a standardized set of assumptions and allocations. In this case, the AFM(S) should identify those assumptions and allocations.

(B) If the predictive RNP capability is resident in the aircraft, then it should provide the ability to identify navigation facilities that are expected to be unavailable, and it should be consistent with the navigation algorithms.

(C) If the predictive RNP capability is to be provided by a ground-based service, the service should be defined to be consistent with the aircraft navigation algorithms, or the AFM(S) should identify the information necessary to reproduce those navigation algorithms.

(D)When RNP is relied upon during extraction from an RNP based operation (e.g. RNP based missed approach), or if operating in an obstacle rich environment, the predictive RNP capability must consider reversion and degraded modes, either in the satellite or ground-based infrastructures. This assurance should support the hazard class for loss of function during these RNP based operations, which are considered to be at least a major failure class. The prediction tool should output/advise when the aircraft to be dispatched will not meet the required continuity requirements of the procedure/route (e.g. if dual equipment must both be operating).

(E) The predictive RNP capability shall automatically report any occurrence of when the total system error may exceed the RNP.

(F) The qualification and verification standards of the predictive RNP capability must be commensurate with its intended use.

Note: Operational considerations for the predictive RNP capability are in Appendix 1 of this AC.

~~(ii) RNP RNAV types 1 and greater. RNP RNAV applications for en route and terminal operations will be part of the transition to free flight. Due to the performance tolerances involved, the sensor-specific issues are not critical.~~

(ii~~i~~) ~~RNP RNAV types less than 1. Due to decreased separation from obstacles and the reduced opportunity for proactive ATC intervention, approach operations demand an exact accounting of sensor-specific issues.~~ The system must provide the ability to designate sensor combinations approved for a specific route or procedure. As described in AC 90-RNP, the FAA plans to implement RNP RNAV ~~approach~~ operations based on GNSS, inertial, and DME/DME. There is no intent to approve other navigation aids for these operations, since their performance is generally inconsistent with the desired level of performance, and the cost of addressing all of the issues associated with other sensor combinations outweighs the operational capabilities they may support. Thus, pilots may fly RNP RNAV ~~approach~~ routes and procedures using:

- GNSS (GPS, WAAS, LAAS)
- GNSS/inertial
- DME/DME/inertial

Note: For example,while providing position solutions for an RNP RNAV approach, ~~T~~the position estimation function of the navigation sensor suite must not use any other contribution from ~~any~~

other ground-based navigation aid (e.g., VOR, ADF, localizer) ~~*while providing position solutions for RNP RNAV operations*~~.

These sensors and sensor combinations must meet the following additional requirements:

(A) There are no unique requirements for GNSS position estimation.

(B) The inertial system must satisfy the criteria of 14 CFR Part 121, Appendix G. For "tightly coupled" GPS/IRU's, the requirements of RTCA/DO-229C, appendix R, apply. If the equipment sustains a coasting capability for RNP RNAV operations, the equipment manufacturer must document the coasting performance capabilities and limitations (i.e., coasting time while sustaining 95% RNP RNAV accuracy at desired RNP RNAV performance levels). This documentation must be consistent with the RNP alerting algorithms for the aircraft.

> *Note: Tightly integrated GPS/IRU systems* ~~*process and monitor*~~*combine GPS* ~~*satellite*~~ *pseudorange measurements* ~~*individually through*~~*and inertial* ~~*information*~~ *data in an integrated filter. These systems*~~*and*~~ *can exclude and remove faulty pseudoranges from the navigation solution to improve upon the GPS computed position and integrity.*

(C) ~~For DME/DME/inertial sensor combinations, the allocation of TSE to the position estimation error shall be 0.16 NM (95%) or larger.~~ The DME ranging accuracy (including the DME sensor) shall ~~also~~ be better than 0.2 NM (95%). Given the DME signal-in-space accuracy, the 95% slant range error for the DME receiver must be less than 0.17 NM, regardless of the receiver's distance from the DME station. The equipment must also provide the pilot the capability to manually deselect a DME facility identified out-of-service (via a Notice to Airmen (NOTAM) or by other means) and a means for the pilot to verify explicit DME exclusion. If the system excludes DME facilities which bias their DME distance to the runway threshold, or corrects for this bias, the system may use ILS DME's as part of the RNP RNAV navigation solution.

> *Note: If a DME facility requires maintenance, ATS providers will NOTAM the facility out-of-service and remove the facility's IDENT feature. However, the facility may still transmit a DME signal and respond to interrogations.*

> *Note: DME receivers meeting the minimum performance standard of TSO-C66c (or earlier) may not satisfy the DME slant range accuracy requirements.*

(4) *Path Definition Requirements*: Section 3.2 of RTCA/DO-236A describes path definition requirements; however, the following exceptions apply:

(i) This AC does not require a radius-to-a-fix (RF leg type) capability. However, equipment with this capability should meet the requirements of RTCA/DO-236A, Section 3.2.3.3. If the equipment does not support RF capability, the system or data process must be able to discriminate between instrument procedures it can and cannot support. For example, if a procedure uses an RF leg, but the equipment is not capable of performing RF legs; the pilot should not be able to access or attempt use the procedure. Also, an acceptable means to satisfy this requirement is to remove procedures with RF legs from the aircraft's database.

Note: Procedures with RF leg types will be used when a curved path route segment is required. ~~*Curved paths will be used only when operationally necessary.*~~ *Most turns should be* *accomplished as fly-by, giving the aircraft the opportunity to define the optimum turn based on current wind conditions.*

(ii) This AC does not require the ability to conduct RNP RNAV holding patterns (see paragraph 8a(7) of this AC); and when conducting conventional holding pattern entries, the RNP RNAV equipment may consider a holding entry point a fly-by waypoint.

(iii) Fix-to-altitude (FA leg type) capability. Manual termination of an FA leg is one acceptable means of satisfying this requirement. But, the equipment must be able to navigate FROM any random fix along a desired track. In this case, the flight crew must manually sequence to the next leg upon reaching their required/desired altitude.

(iv) Direct-to-fix (DF leg type) capability. If the equipment provides a Direct-To capability, manually proceeding direct-to a fix is one acceptable means to satisfy this requirement.

(5) *Estimate of Position Uncertainty (EPU)*: There is no requirement to display an EPU.

(6) *Along-track reference points*: This AC does not require a capability to insert along-track reference points. If the equipment permits the flight crew to insert along-track reference points, Section 3.2.2.2 of RTCA/DO-236A applies.

(7) *RNP Holding*: This AC does not require the capability to accomplish RNP holding. However, the aircraft must have the ability to accomplish a conventional holding at any fix. The flight crew may accomplish the holding pattern manually. Equipment providing an RNP RNAV holding capability should meet the requirements of RTCA/DO-236A, Sections 3.2.4.1 (and subsections), and Section 3.7.2.2.3.1, including the revised entry procedure. The equipment must distinguish between conventional and RNP RNAV holding and keep the flight crew aware of the anticipated holding entry procedure. The AFM(s) should state whether or not the equipment provides RNP RNAV holding capability.

Note: There is no plan to introduce RNP RNAV holding in the United States. At the time of issue of this AC, many policy and acceptance questions remain unanswered. For example, fly-ability of fly-by entries into RNP RNAV holding patterns, charting RNP RNAV holding patterns, labeling RNP RNAV holding on the Instrument Approach Procedure (IAP), Air traffic Control (ATC) and flight crew familiarity with RNP RNAV procedures, and execution of RNP holding by non-RNP aircraft all have unanswered questions and concerns.

(8) *Fixed-Radius Transition*: This AC does not require the capability to execute fixed-radius transitions. However, aircraft with fixed-radius transition capability should meet the requirements of RTCA/DO-236A, Section 3.2.5.4.2. If the equipment does not support fixed-radius transitions, the system or data process must include a capability to discriminate between routes that it can and cannot support. For example, if a route uses a fixed-radius transition, but the equipment is not capable of performing fixed radius transitions, the pilot should not be able to access or use that route. An acceptable means of satisfying this requirement is to remove routes with fixed-radius transitions from the on-board database. The AFM(s) should state whether or not the aircraft's equipment provides this capability.

(9) *Selection of RNP RNAV Type*: This AC does not require the capability to manually select the RNP RNAV type.

The equipment shall support the following standard RNP RNAV types:

- RNP-0.3 RNAV: instrument approach procedures
- RNP-1 RNAV: departure procedures, arrival procedures, approach transitions, missed approach procedures
- RNP-2 RNAV: all other operations

If the equipment also provides a means to select or modify the RNP RNAV type, then Section 3.7.2.1.3.1 of RTCA/DO-236A applies.

RNP RNAV applications are not limited to the types identified above. These standard RNP RNAV types are for standard applications, which all aircraft should support. In addition to the standard RNP RNAV applications, some aircraft may support RNP RNAV types associated with applications identified in the navigation database or with pilot entry of the RNP RNAV type identified from the chart.

Note: If the equipment does not support non-standard RNP RNAV types, then the system must include a capability to discriminate between RNP RNAV procedures it can and cannot support. For example, if an RNP RNAV procedure uses an RNP-0.3 RNAV missed approach segment, but the system does not support non-standard RNP leg types, the pilot should not be able to access or use the procedure (since the default RNP RNAV type in the terminal area is 1 NM).

(10) Section 3.7.5.1.1, Flight Progress, of RTCA/DO-236A. This AC requires a course deviation indicator (CDI) located in the pilot's primary field of view (a scalable electronic MAP cannot substitute for a CDI). When the equipment does not provide a scalable ~~course deviation indicator (~~CDI~~)~~, a fixed-scale CDI is acceptable as long as the CDI demonstrates appropriate scaling and sensitivity for the intended RNP RNAV type. The AFM(s) should state which RNP RNAV types and operations the aircraft supports and the operational effects on the CDI scale. Differences in CDI scales from one RNP RNAV type to another may require operational procedures to check and affirm the CDI scale against the RNP RNAV type. With a scalable CDI, the scale should derive from the selection of RNP RNAV, not from a separate selection of CDI scale. Also, if the equipment uses default RNP RNAV types to describe the operational mode (e.g. en route, terminal area and approach), then displaying the operational mode is an acceptable means from which the flight crew may derive the CDI scale sensitivity.

b. Exceptions unique to RNP RNAV types greater than 4 (RNP RNAV > 4).

(1) This AC does not require compliance with Section 2.2, Containment Integrity, and 2.3, Containment Continuity, of RTCA/DO-236A. Airspace design and air traffic operations will ensure operational containment occurs.

(2) This AC does not require compliance with Section 3.1.3, Containment Radius, of RTCA/DO-236A. However, Automatic Dependent Surveillance (ADS) applications may require the containment radius as an input value to determining the Navigation Uncertainty (NUC).

(3) This AC does not require compliance with those areas of Section 3.7.2.1.1.1, Flight Planning, of RTCA/DO-236A pertaining to "RNP-4 RNAV or less airspace."

(4) The equipment should support the intercept of a pilot-defined course to a fix. If the equipment provides this capability, it shall meet the requirements in Section 3.7.2.2.2.1, User-Defined Course-to-a-Fix, of RTCA/DO-236A.

c. Exceptions unique to **RNP-0.3 RNAV to RNP-4 RNAV.**

There are no unique exceptions for RNP-0.3 RNAV through RNP-4 RNAV.

Note: At the time of publication of this AC, RTCA Special Committee-181 was at work defining criteria for RNP RNAV types less than RNP-0.3 RNAV. A future revision of this AC will include this new criteria.

9. INSTALLATION ISSUES.

a. Failure Classification.

(1) From en route through Category I precision approach, AC 25.1309-1; AC 23.1309-1; AC 27-1; or AC 29-2 defines the loss of navigation information as a major failure condition for the aircraft. RNP RNAV navigation data is “misleading” when unannunciated position errors exist. For en route, terminal, and Non Precision Approach (NPA) with no vertical guidance, presenting misleading information to the flight crew is a major failure condition for the aircraft. During an approach with vertical guidance (LNAV/VNAV, RNP-0.3 RNAV), presenting misleading information to the flight crew is also a major failure condition. At the time of publication of this AC, criteria for more demanding operations (less than RNP-0.3 RNAV) was under development.

The following table provides a summary of failure classifications:

	En route/ Terminal Area/ NPA (LNAV)	Approach with Vertical Guidance (LNAV/VNAV) (APV)	Precision Approach (Cat. I)
Loss of Navigation	Major	Major	Major
Misleading Information *	Major	Major	Hazardous

** Note: Determination of the hazard classification is dependent upon the TERPS obstacle clearance surface and assumes use of a Collision Risk Model (CRM) to achieve the Target Level of Safety. These failure classifications with their associated design assurance levels may not be adequate for an Obstacle Rich Environment (ORE). An ORE would require other risk mitigation techniques, special equipment and special authorization.*

(2) The applicant must conduct a safety assessment of the RNP RNAV equipment installation to verify that design errors and failure modes meet the probability requirements for each appropriate failure classification. The latest version of AC 25.1309-1, AC 23.1309-1, AC 27-1, or AC 29-2 provides an acceptable means to show the equipment complies with pertinent airworthiness requirements.

b. Airplane/Rotorcraft Flight Manual. Each installation of RNP RNAV equipment requires an airplane or rotorcraft flight manual supplement (or, for aircraft without an FAA approved flight manual, a supplemental flight manual) containing the limitations and operating procedures applicable to the installed equipment. When an applicant seeks an RNP RNAV airworthiness approval, the flight manual supplement or supplemental flight manual must contain at least the following information:

(1) A statement indicating the aircraft meets the requirements for RNP RNAV defined by AC 20-RNP and demonstrated the established minimum RNP RNAV capabilities. This documentation must include the phase of flight (e.g. oceanic, en route, terminal area, approach), mode of flight (e.g., manual; FD on or off; and/or AP on or off) and sensor limitations, if any (e.g. GPS required).

(2) Any conditions or constraints on path steering performance (e.g., A/P engaged, FD or manual control with CDI or MAP display).

(3) The criteria used for the demonstration of the system, acceptable normal and non-normal procedures, the demonstrated configurations, type of facilities used, and any constraints or limitations necessary for safe operation.

(4) Any conditions or constraints on Navigation Performance, such as the type of navigation facilities used (e.g., GPS, WAAS) as a basis of certification. The AFM(s) may contain a statement regarding unacceptable types of facilities or conditions.

(5) If compliance to the continuity requirements of this AC has been shown through a combination of navigation sensors, the AFM should contain a statement that "Continuity of RNP navigation has been demonstrated only where the operational environment supports all of the following types of sensors: <insert type of sensors for which credit is being sought>.

c. Flight Technical Error (FTE).

(1) Standard Values for FTE. The applicant must verify maintenance of FTE (95% of the flying time) during straight-path segments per the table below (for manual, FD, and AP operations, as applicable). If an applicant seeks approval for RNP RNAV curved-path segments (i.e. RF leg types), the applicant must conduct the FTE assessment following the guidance in paragraph 9.c(2).

Manual Steering

Full-Scale Deflection (CDI/HSI)	95% FTE
+-4 to +-5 NM	2.0 NM
+-2 NM	1 NM
+-1 NM	0.8 NM
+-0.3 NM	0.25 NM

Coupled Operation

	95% FTE	
	Flight Director	Autopilot
LNAV mode	0.50 NM	0.25 NM
APPR mode	0.25 NM	0.125 NM

For hand-flying using raw data, flight test flight crews collected data in a variety of aircraft that substantiate the values in the table above . Additional flight testing is not necessary. For flight director and autopilot, the values are based on typical performance. The FTE should be demonstrated in each phase of flight and each autopilot mode. This demonstration can be conducted as part of the evaluation described in paragraph 9.d.

(2) Alternate levels of FTE. If the applicant allocates smaller values to path steering error (i.e., FTE), the applicant must substantiate the smaller values.

A combination of simulation and flight tests may validate alternate levels of FTE. If the validation uses simulator testing, sufficient flight tests must verify the simulator results represent the true in-flight characteristics. The confidence level in the FTE performance results should be at least 95% (i.e., a 95% confidence that the true flight technical error is less than the assured flight technical error). The allocation of total system error (reference Section 2 of RTCA/DO-236A) should also be consistent with the distribution of FTE; a normal distribution may not be applicable. Additionally, the FTE evaluation should match the types of RNP RNAV procedures flown (e.g., representative leg types and leg geometry), aircraft configurations (e.g., map display; CDI; flight director/autopilot on or off, coupled or uncoupled), representative environmental conditions, and representative pilot qualification and experience. The FTE evaluation may segregate flight data on stabilized portions of straight segments and flight during curved segments and/or during leg-to-leg captures. The plan for the FTE evaluation should be accepted by the FAA prior to collecting any new data.

d. Interface to Flight Guidance System (FGS).

(1) Evaluate steering response with the flight director and/or autopilot coupled to the RNP RNAV equipment during a variety of different track and mode changes. This evaluation should include transition between navigation and flight director/autopilot modes, as applicable, (e.g., from en route to approach transition to approach to missed approach, from LNAV to approach mode to LNAV). Also, the applicant should evaluate all available display sensitivities.

(2) The applicant should complete several fly-by turns in varying wind conditions. These turns should verify that the RNP RNAV equipment accomplishes the turn as a fly-by way-point and provides a smooth transition onto the next leg in the flight plan. RTCA/DO-236A Section 3.2.5.4 defines fly-by turns.

(3) If the RNP RNAV equipment can be coupled to an autopilot, the testing should verify appropriate annunciation(s) such as when arriving at a waypoint.

(4) The testing should verify that execution of the Direct-To functions and associated aircraft heading changes do not overshoot desired tracks or cause "S" turns.

(5) Verify acceptable autopilot response to an RNP RNAV fault by pulling the circuit breaker for the RNP RNAV equipment. Applicants should complete this test in each of the RNP RNAV and autopilot modes, as applicable.

e. Interface to Inertial Reference System. If an inertial system is part of an RNP RNAV-compliant system, the fidelity of the real-time modeling (reference paragraph 8.a(2)(ii)) of the inertial performance should be verified for maneuvering flight, either by flight test or by a simulation tool that has been validated against flight test data. The model of inertial performance should also be valid for the different types of alignment, high latitudes and extended flight durations.

~~e.~~f. Failure Modes/Annunciation's. Identify any failure modes potentially affecting RNP RNAV capability. Verify annunciation of RNP RNAV failure modes exists. This verification should be compatible during manual flight and with the aircraft's FGS and to ensure unambiguous flight crew action(s). Typical failure modes include loss of electrical power, loss of signal reception, and RNP RNAV equipment failure (including degradation of navigation performance resulting in a loss of RNP RNAV containment integrity). The applicant must also verify that a visible alert within the flight crew's primary field of view occurs with a loss of navigation capability and/or loss of RNP RNAV containment integrity. An audible alert should accompany the visible alert.

Predictive RNP Capability

Operational Considerations

The predictive RNP capability should support the following:

1. Identify each RNP level required along the intended route of flight.

2. Identify installed sensors that are operating on the specific aircraft to be dispatched and to be used for RNP RNAV operations. For example,

a) (If GPS isn't on the MEL) is the GPS operating?

b) Are sufficient DME channels operating? Presumably, without GPS, the ANP computation is degraded if fewer DME channels are available, (e.g, if a DME radio has failed.)

c) For each RNP level, what coasting time is supported by the installed AHRS or (tightly or loosely coupled) IRS?

d) If not already MEL items, are all (dual) equipment installed such that RNP availability requirements are met for the flight?

3. Identify the available satellite and/or ground-based infrastruture.

a) Navaids loaded into the FMS of the aircraft to be dispatched. (The FMS only uses navaids loaded in the nav database.)

b) NOTAMs on satellites and/or ground based navaids (blackballed navaids)

c) NOTAM restrictions on navaids (e.g, service volume or sector)

4. Identify FMC version; that is, identify the basis of the RNP Alert in the aircraft to be dispatched:

a) EPU (specific to aircraft's FMS version) that can be achieved with available satellite or ground-based infrastructure

Note: EPU may depend not only on the specific RAIM algorithm, but also how RAIM is incorporated into position estimate or considered in the alert.

b) FTE basis for triggering an RNP Alert, that is, the FTE used in the ANP computation, considering

(i) Standard or installation-specific FTE budget

(ii) Manual, or coupled autopilot or FD FTE budget

c) For each RNP segment along the route, whether manual, or autopilot or FD coupling is to be flown.

5. Output reports

a) Regions (segment of route) for which specified RNP cannot be achieved.

b) Estimated ANP along intended route, including missed approach and alternates.